Calibration and Analysis of Global Latent Heating Estimates Using Passive and Active Microwave Sensor Data

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Project hypothesis: Calibrate a method for deriving atmospheric latent heating distributions over oceanic regions from passive microwave radiometer observations from multiple satellite platforms, using an extended time series of high-resolution, combined radar-radiometer estimates of precipitation and latent heating vertical structure.

Objectives & deliverables:

- create a general look-up table, or database, relating latent heating vertical structure to observed microwave radiances, based upon combined radar-radiometer estimates of latent heating.

- incorporate latent heating database into a Bayesian method for estimating latent heating vertical structure from microwave radiances and radiance horizontal texture.

- evaluate method using coincident, combined Precipitation Radar-TRMM Microwave Imager estimates of heating, as well as independent rawinsonde analyses of heating.

- apply the latent heating estimation method to 7+ year TMI data record; 2+ year AMSR-E data, as well as SSM/I data overlapping these periods (instantaneous, 0.5 degree; monthly, 2.5 degree).

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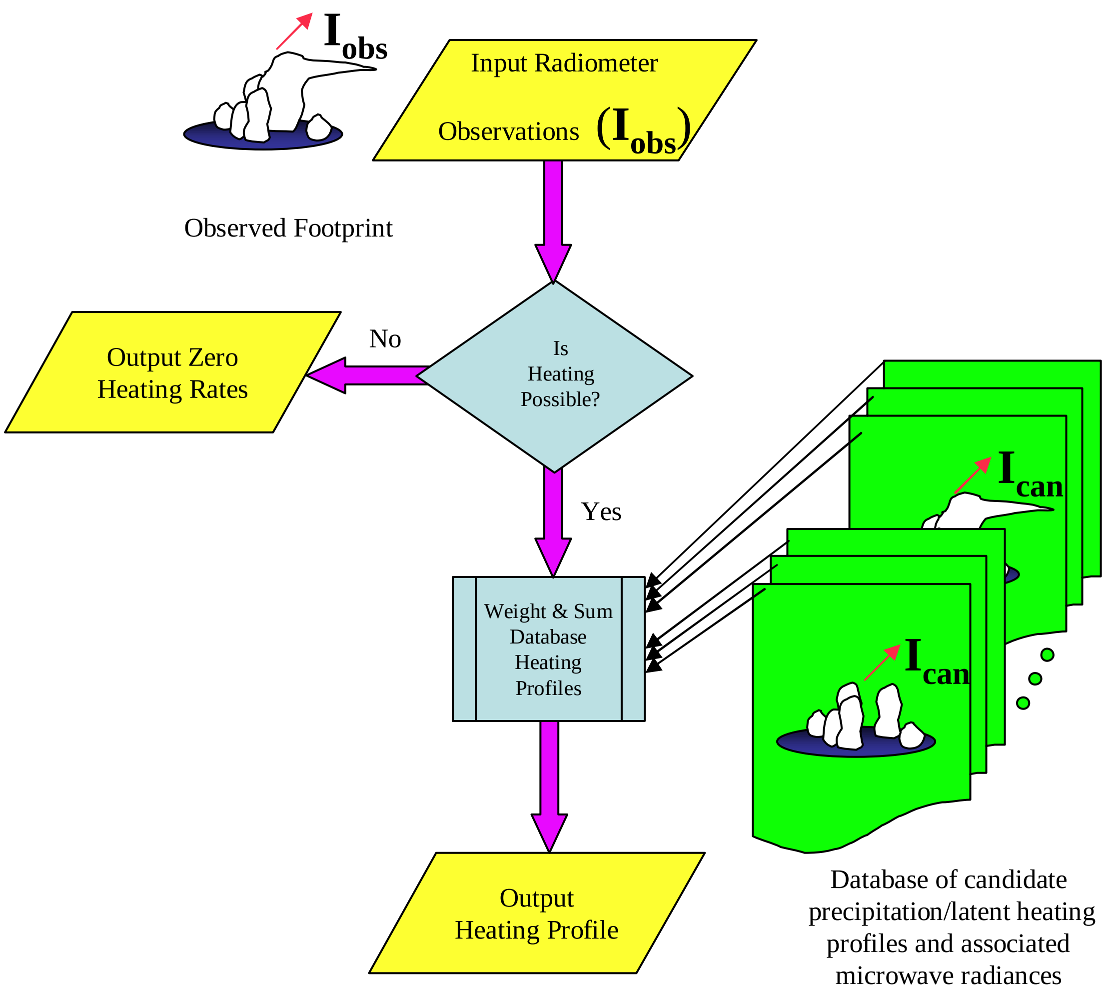
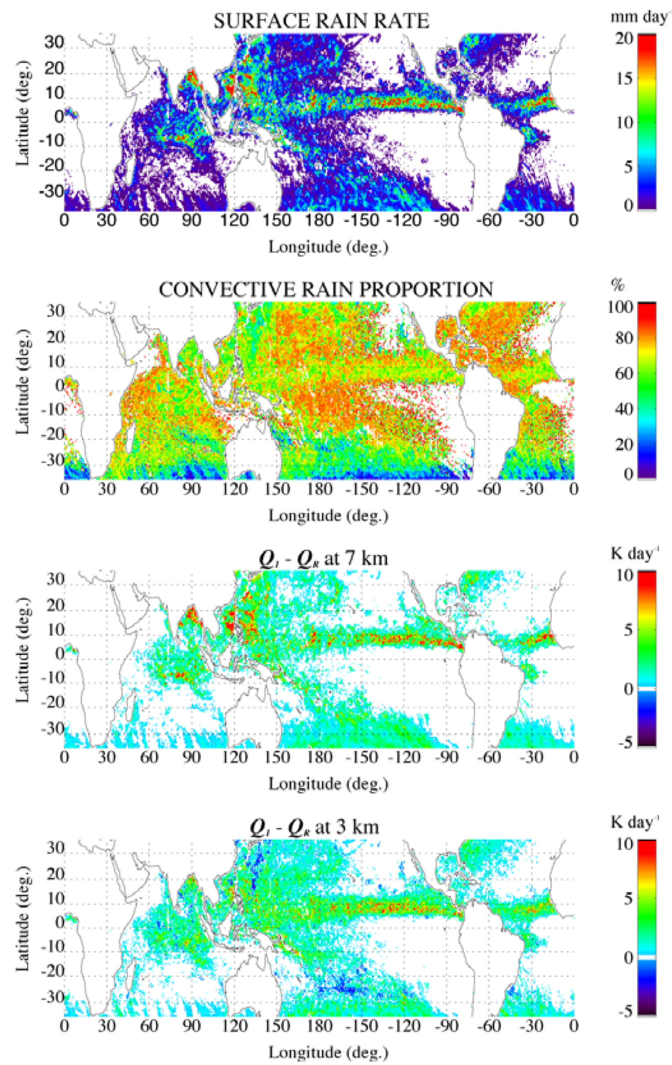
Technical approach and/or methods:

- Bayesian methodology for estimating rain rates and latent heating based upon satellite passive microwave observations is well established (Kummerow et al. 1996, 2001), Olson et al. (1996, 1999, 2005 in review), Grecu and Olson (2005 accepted).

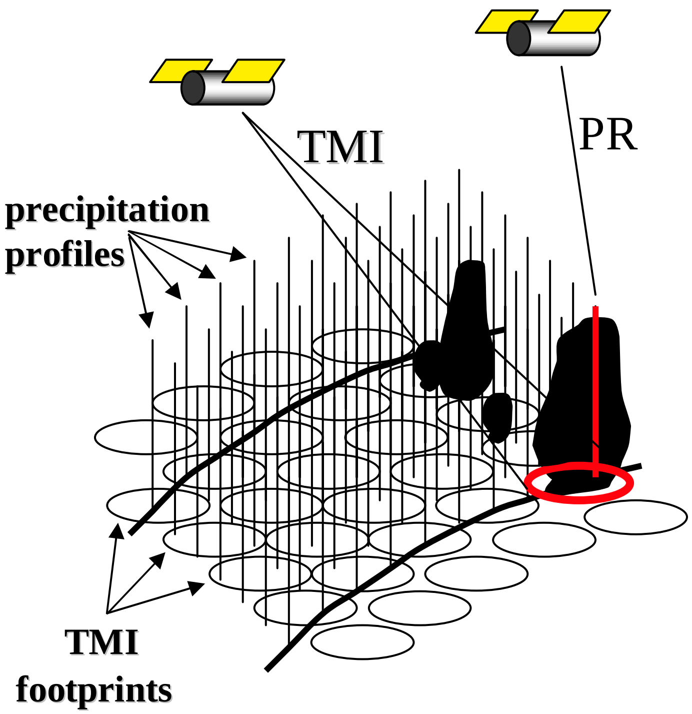


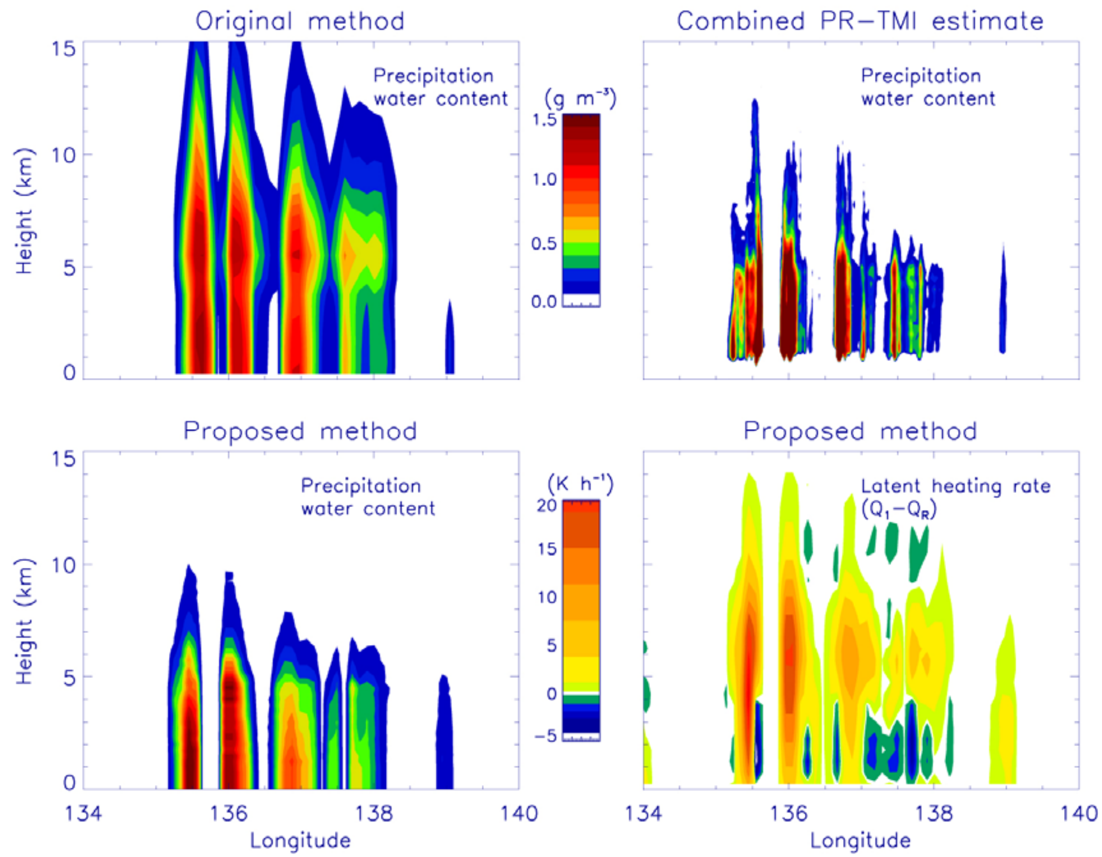


Technical approach and/or methods:

- Construction of the supporting database for the Bayesian method using combined Precipitation Radar-TRMM Microwave Imager observations is a crucial advance (Grecu et al. 2004). This yields extensive database of vertical precipitation profiles and associated microwave radiances.

- A latent heating profile is assigned to each vertical precipitation profile using a method similar to that of Shige et al. (2004). This method matches CRM-simulated profiles to precipitation profiles based upon convective/stratiform classification, profile depth, precipitation at surface and base of melting layer (stratiform), and normalizes profiles by precipitation fluxes. Needs work!

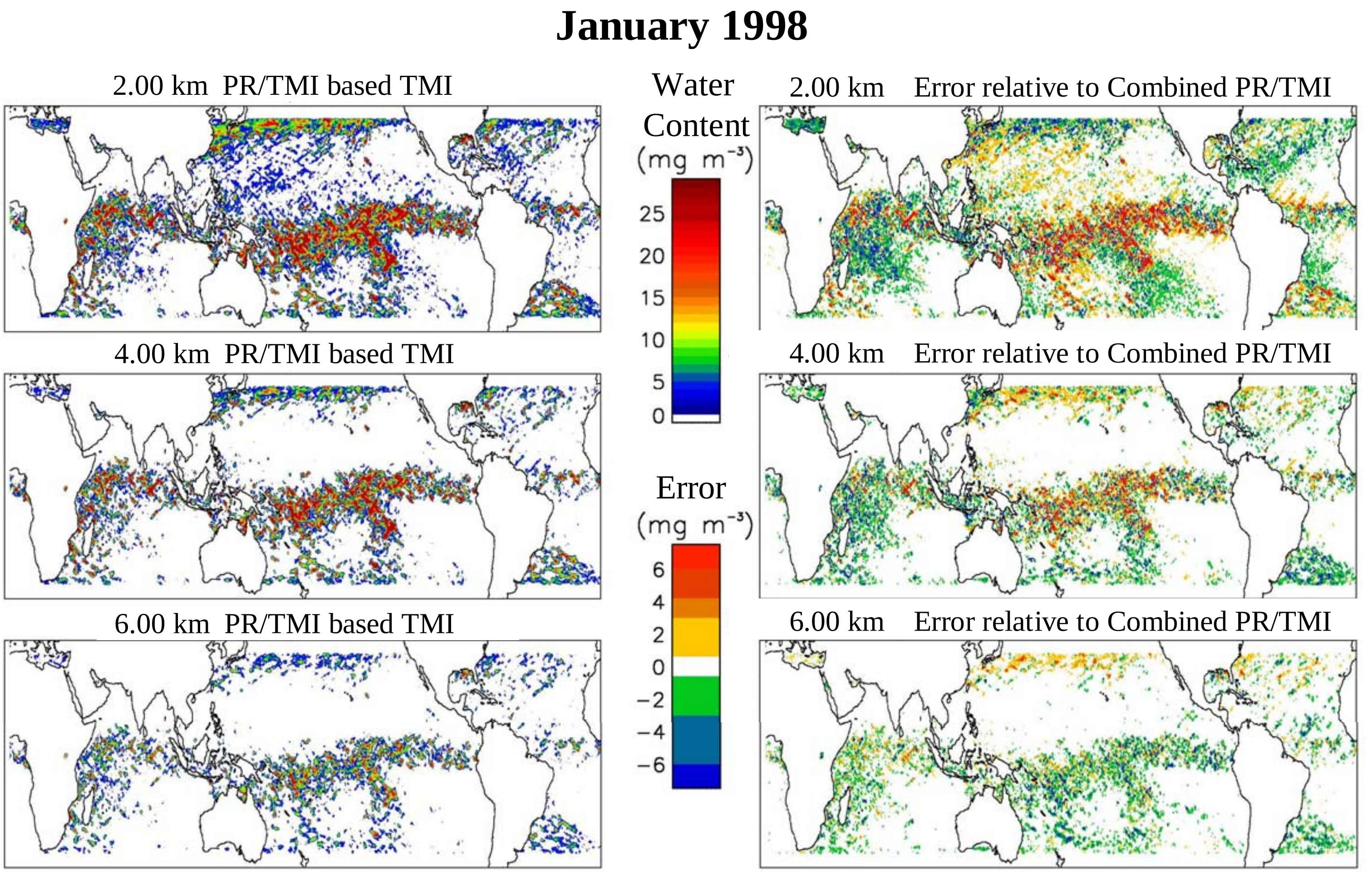




Technical approach and/or methods:

- Evaluation of rain rate and latent heating estimates using independent, combined PR-TMI estimates, as well as rawinsonde analyses (Grecu et al. 2005, accepted).

- Error models describing the uncertainties in rain rate/heating are under development (Olson et al. 2005, in review). Primary concern are seasonal/regional systematic errors and how they might be reduced.



Data set needs:

- TRMM PR and product data (20.2 Gb/month) used for calibration and "validation".

  cal/val: 12 months ~ 250 Gb

- TRMM TMI data (6.6 Gb/month)

  cal/val: 12 months ~ 80 Gb

  val (pre-boost): 6 months ~ 40 Gb   7 year period: 550 Gb

- other radiometers: 2-3 SSM/I and Aqua AMSR-E data (26.4 Gb/month)

  val: 6 months ~ 160 Gb   7 year period: 1900 Gb

- Rawinsonde analyses (small)

Project outputs:

- instantaneous 0.5 degree estimates (0.5 Gb/month/sat.)

- multi-radiometer, monthly 2.5 degree estimates (small)

- ftp transfer

Potential collaborations:

Are precipitation/latent heating estimates consistent with other components of the global water and energy budgets (ID'd as GAP)?

- Water cycle: Adler, Wentz, Curry, Fetzer, Famiglietti, Schlosser, etc.
- Energy cycle: Curry, Wielicki, l'Ecuyer, etc.

Important outside linkages/resources:

- Cloud-resolving model group at MAPB (W.-K. Tao, S. Braun, etc.).
- Passive microwave "community" algorithm team (Kummerow, Iguchi, etc.) for TRMM-GPM.
- Goddard Modeling and Assimilation Office (Arthur Hou) for GCM assimilation.
- TSDIS/PPS (Erich Stocker) for some data processing.

Expected contribution to the NEWS objective:

- cross-calibrated precipitation and latent heating profile datasets based upon passive microwave observations from several platforms (monthly 2.5^{o}; 7 year span). Comparisons with Goddard GEOS-5 simulations will be performed.

- instantaneous, 0.5^{o} estimates of precipitation and latent heating from several platforms will be tested in Goddard GEOS-5 assimilations. Should lead to improved representations of climate variability associated with the intensity and frequency of occurrence of precipitation systems.

- error estimates for these products will be available.

Issues, needs, and concerns:

- realism of cloud resolving model simulations still important - Wei-Kuo Tao.

- latent heat profiling over land is difficult: although ice-phase precipitation produces signal, rain signal is not easily distinguishable from surface emission. We can easily "produce" estimates but their reliability is less certain.

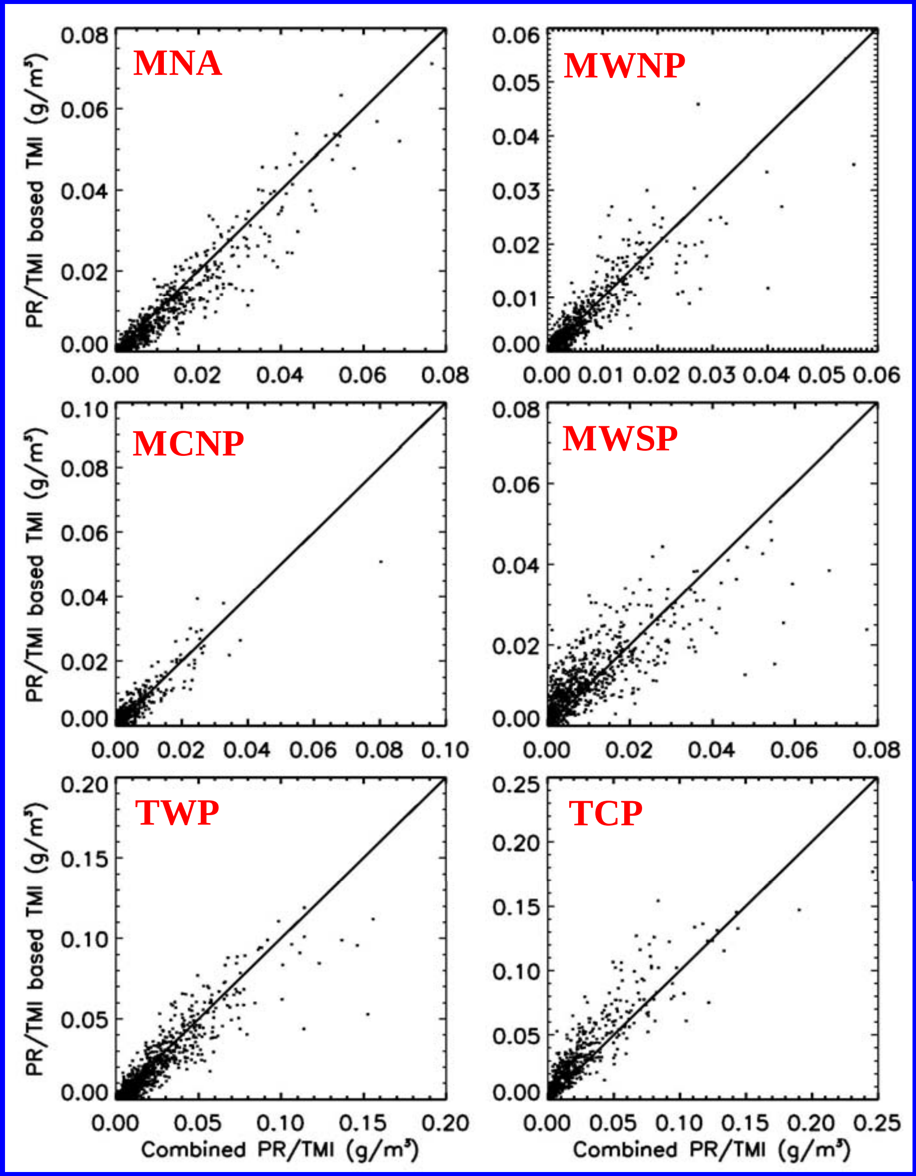
- snow and mixed-phase precipitation can be best accomplished using higher-frequency microwave channels (150 - 183 GHz), currently on AMSU-B, but general calibration of these estimates will require spaceborne radar like CloudSat, future DPR on the GPM core.

Regional Comparisons - July 2000

Region	Lat	Lon
MNA	30-37N	45-75W
MWNP	30-37N	140-170E
MCNP	30-37N	150-180W
MWSP	30-37S	150-180W
TWP	0-10N	130-160E
TCP	0-10N	120-150W

- compare monthly, 0.5º x 0.5º precipitation water contents at 2 km altitude.

- largest bias (+20% in TCP); others (< -5%bias).



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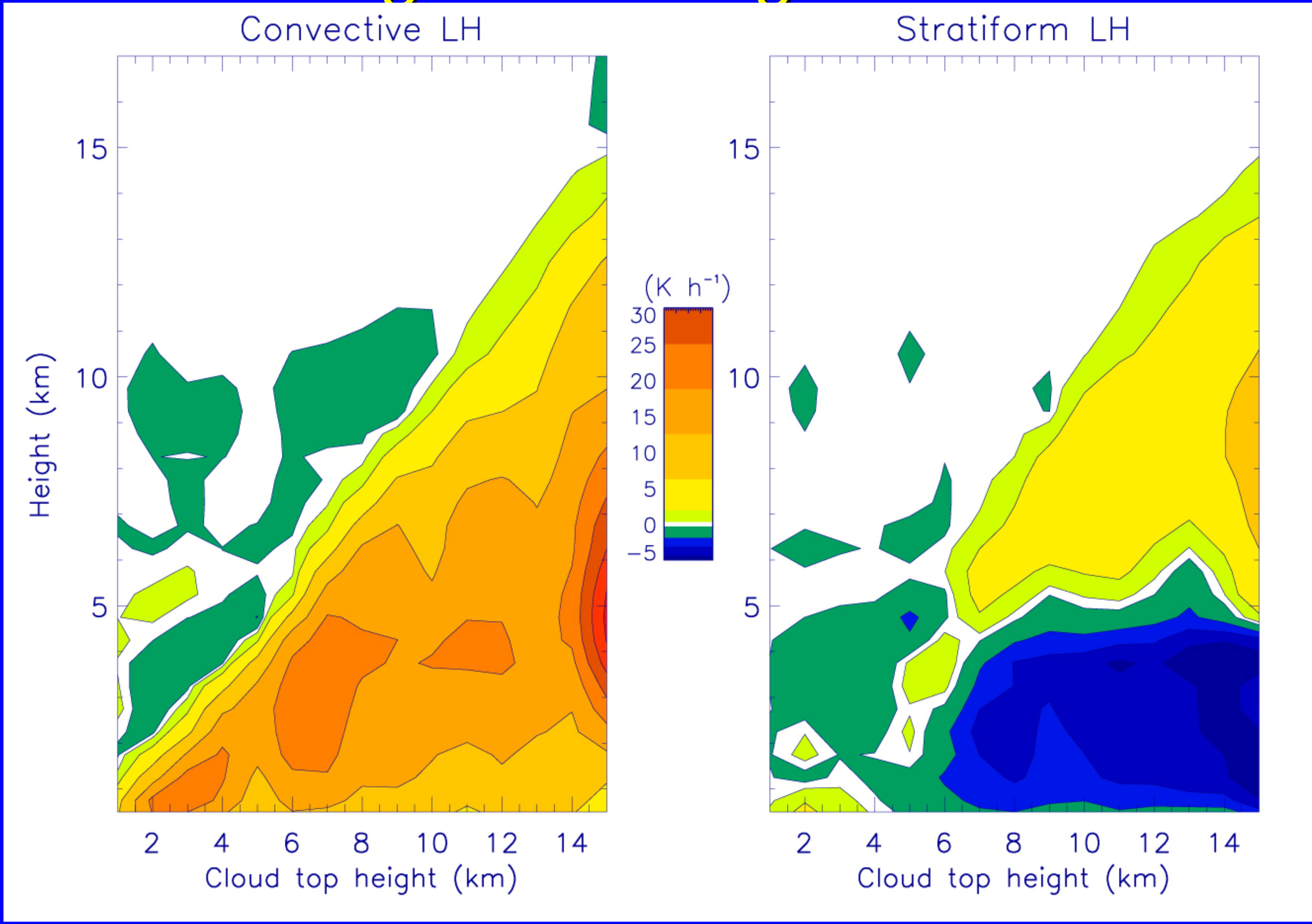
Latent Heating Profile Assignment to Database



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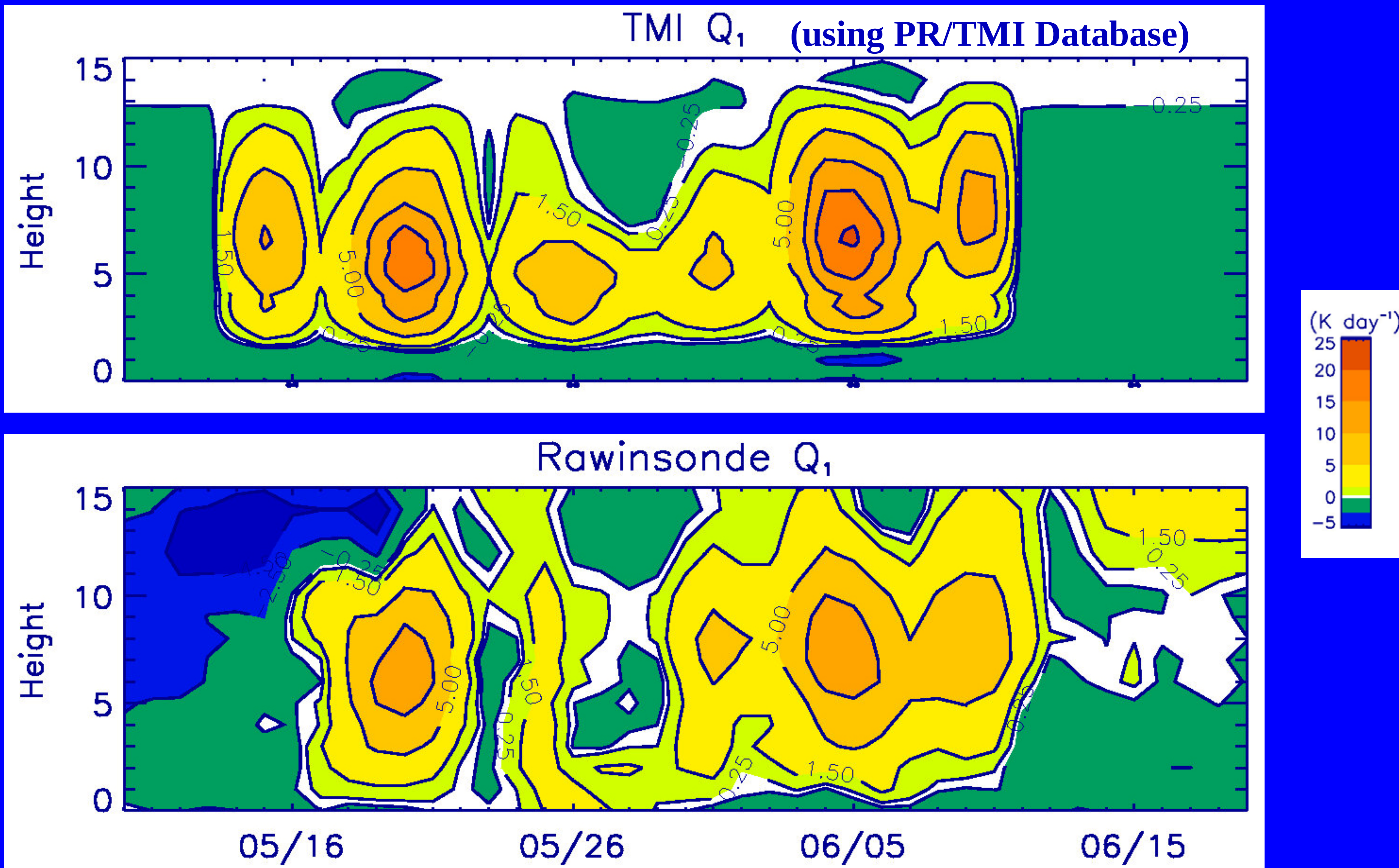
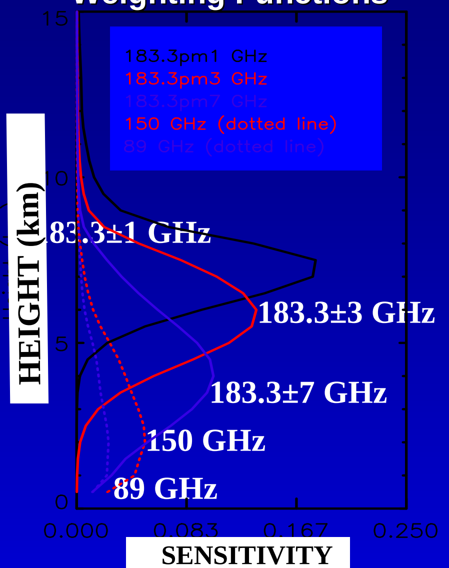
Latent Heating Estimation- PR/TMI Database



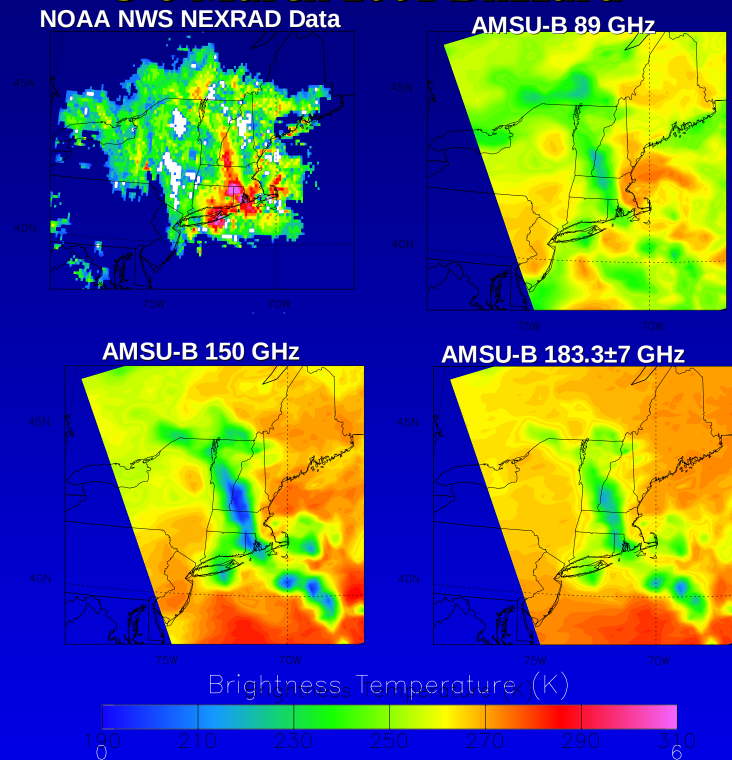
Johnson and Ciesielski (2002)

Advantages of Higher-Frequency Channels on GMI Radiometer

Weighting Functions

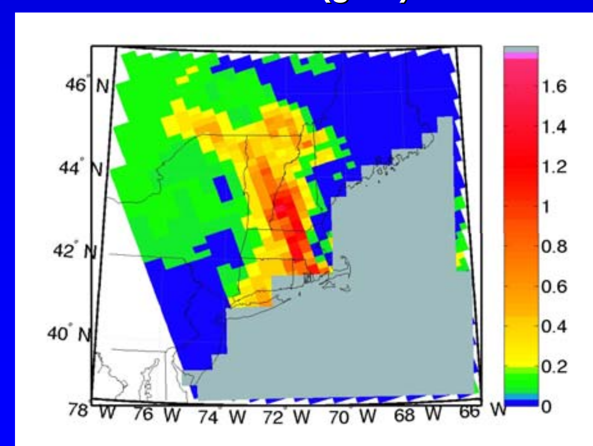


5-6 March 2001 Blizzard



• the proposed GMI higher-frequency channels will be similar to AMSU-B channels at 150 and 183.3 GHz, but with higher spatial resolution. Weighting functions at left show that lower-frequency channels such as 89 GHz will be sensitive to variations in surface emissivity, making precipitation interpretation ambiguous (see land/ocean contrast near NJ and ME coasts).

Snow water content (g/m^3) near surface



• water vapor absorption mostly obscures surface emission at 150 and 183.3 ± 7 GHz, revealing brightness temperature depressions due to scattering by snow particles. A physical algorithm is used to interpret the snow signatures, yielding the estimated low-altitude snow equivalent water contents at right. Drier atmospheres would necessitate use of channels closer to the center of water vapor band at 183.3 GHz.

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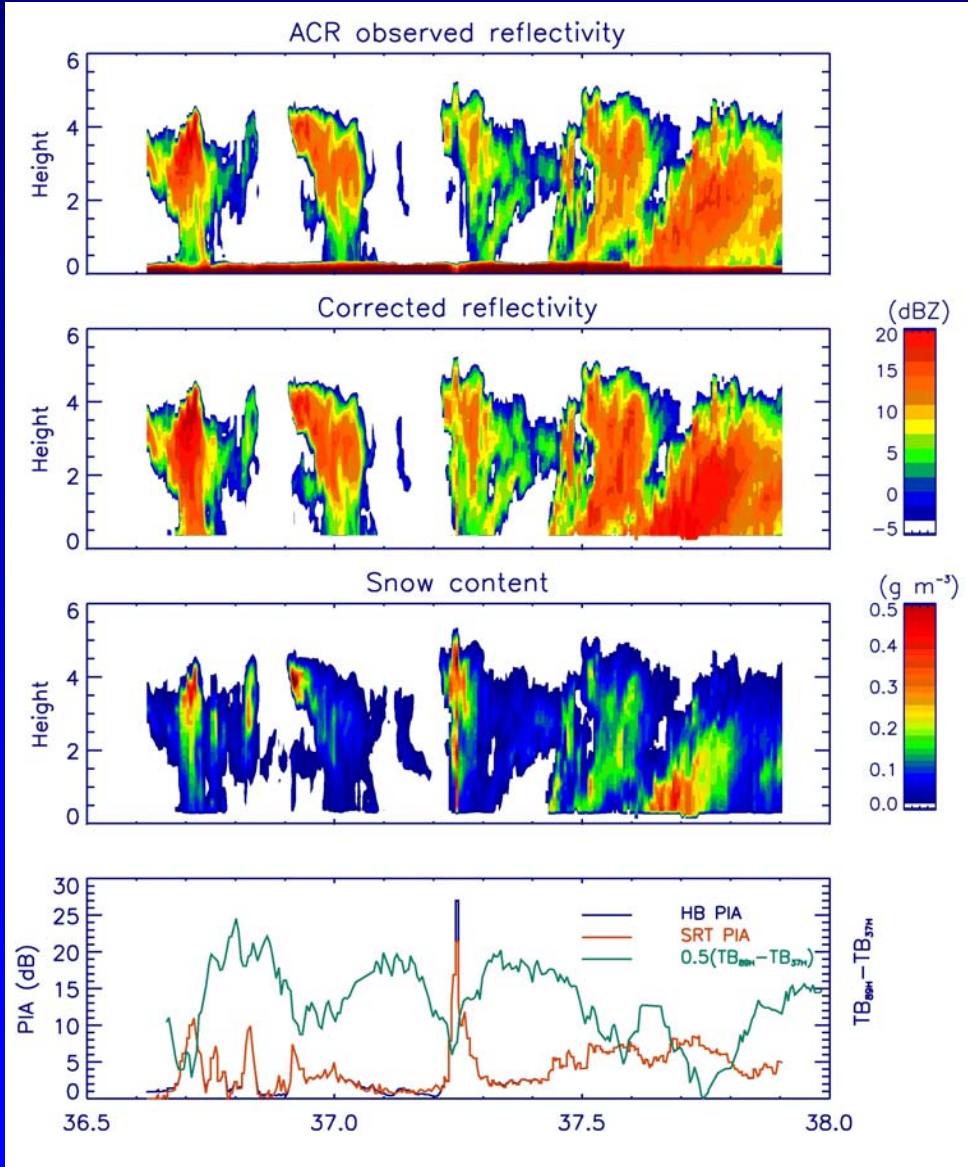
Cloud Radar Retrieval of Snow from Wakasa Bay Experiment



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